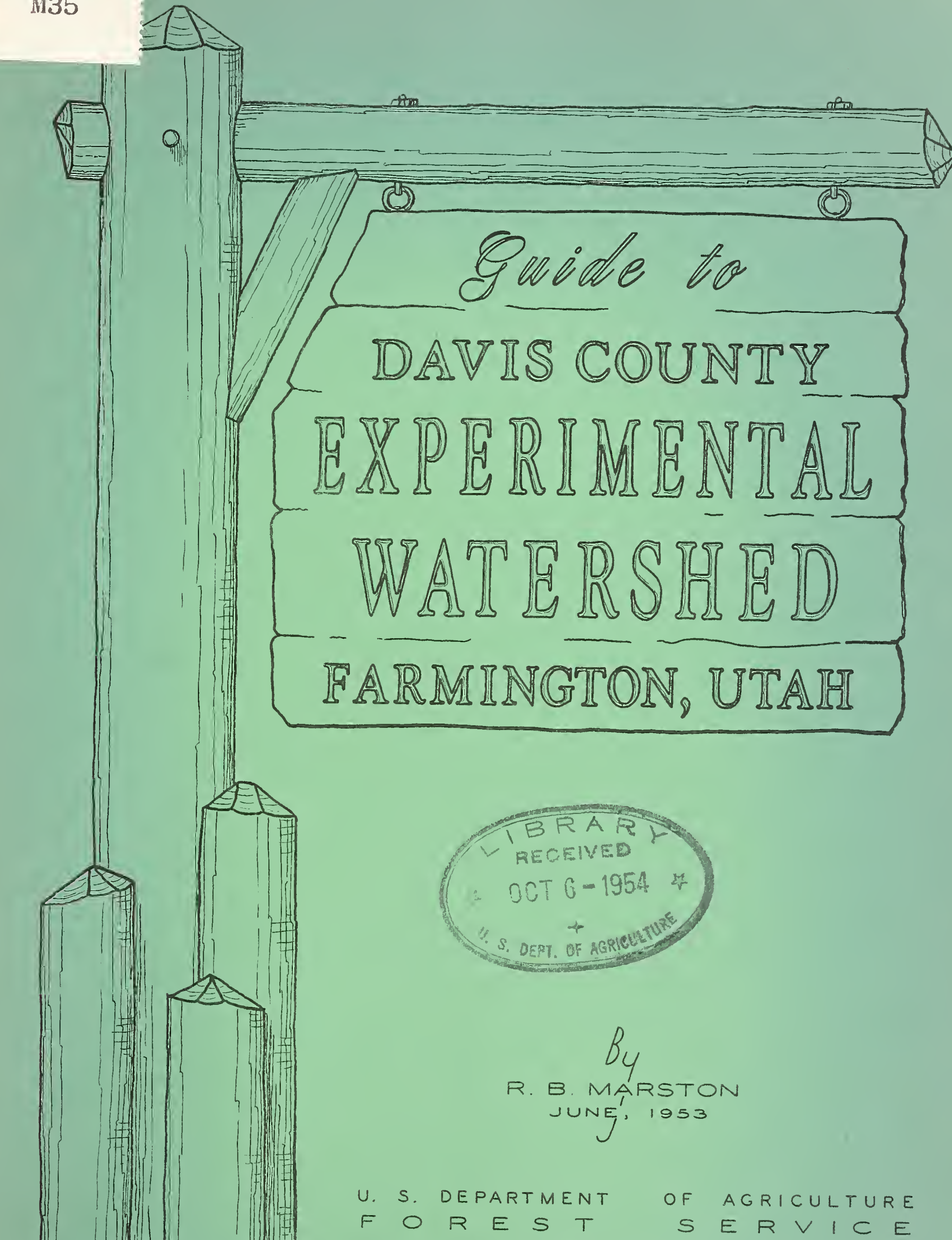

Guide to DAVIS COUNTY EXPERIMENTAL WATERSHED FARMINGTON, UTAH

By
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FOREST SERVICE
INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION
OGDEN, UTAH
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FOREWORD

The Davis County Experimental Watershed is one of several research areas used by the Intermountain Forest and Range Experiment Station for studying problems of wildland management. Situated in the Wasatch Mountains east of Farmington in Davis County, Utah it lies wholly within the boundaries of the Wasatch National Forest. It embraces an area of about 28,000 acres, including the watersheds of several perennial streams that drain into Great Salt Lake. The area is representative of much of the steeply sloping forest-, brush-, and grass-covered mountain lands of northern Utah on which serious problems of flood control and water yield have developed in recent years.

Research in the Davis County Experimental Watershed began in 1930 following the occurrence of highly destructive mud-rock floods from several of the watersheds in that locality. Efforts were first directed to the diagnosis of the flood causes and to the development and application of flood prevention measures on the headwater lands. These initial efforts were highly fruitful but did not provide all of the information needed for the proper management of steep watershed lands. Beginning in 1934 research was broadened and intensified. Continuous measurements of streamflow were begun on many of the streams. Numerous gages were set out on the watersheds to record precipitation. Various types of plots were established, some to measure the response of plant cover to land treatment and some to measure the effect of plant cover on consumptive use of water, on surface runoff, and on soil erosion. The area has thus become an outdoor hydrologic laboratory for studying all phases of watershed behavior, and is visited each year by many hundreds of people, including conservationists from all over the world.

This guide was prepared for visitors. It includes a brief sketch of the flood history of the area. A map shows the location of a scenic loop road and a number of points of interest along the road. This is followed by descriptions of these points of interest. An annotated list of publications is also attached for those who wish more detailed information about the research findings to date.

HISTORICAL HIGHLIGHTS

The lands within Davis County Experimental Watershed have a unique history from which many lessons can be learned about the handling of steep watershed lands. Following are the chronological highlights of this history:

1. Davis County pioneers established homes and farms on the fertile valley lands adjacent to the steep mountains about 100 years ago. Many of them also acquired title to part of the mountain lands. They diverted water from the several streams for irrigation. They cut trees and dragged logs from the mountains to build homes and barns. They also allowed their cattle and sheep to graze on the mountain slopes. The people prospered for more than a half a century, unaware of the damage being done to their watersheds.

2. Some minor summer storm floods occurred in 1878, 1901, and 1906. Soon after that they increased in frequency and intensity. A churning mass of huge rocks, mud, and other debris issued from Bairs Creek in 1912. The state road was covered by rocks from a flood out of one of the canyons on September 15, 1918. Floods of much greater violence issued from several more canyons in 1923. Still more floods came in 1930. During 1923-30, these floods took a toll of 6 lives and caused more than $1 million damage. Many homes and farms were completely destroyed.

3. The local people organized a Flood Control Committee in 1930 and called upon the Governor of Utah for help. The Governor appointed a Flood Control Commission to investigate the flood causes and to recommend remedial measures. The Flood Control Commission, composed of foresters, geologists, engineers, bankers, livestock men, and others, concluded that the mud-rock floods were of unprecedented magnitude and violence in recent geologic time and that they were caused by depletion of the plant cover on the headwater lands due to man-caused fires and to overgrazing by livestock. The committee recommended a program of increased fire protection and restricted grazing to prevent further deterioration of the watershed and of reseeding and planting to promote the restoration of the plant cover.

4. The local people petitioned Congress to extend the boundary of the Wasatch National Forest to include their watershed lands. They also petitioned Congress to provide money to purchase the private lands inside the forest boundary and place them under Federal ownership and supervision.

5. During the period 1933 to 1939, some 1,300 acres of flood-source land in Parrish, Barnard, Ford, Davis, Steed, and Farmington watersheds were contour trenched and seeded by the Civilian Conservation Corps. This work was concentrated on about 10 percent of the watershed lands, mostly in the headwaters. The contour trenching, seeding, purchase of land, construction of several downstream debris

basins, and building of an access road cost $300,000; or about $230 per acre of flood-source land. When the $1,053,589 of flood damages are added to the cost of the flood-control measures, the total cost to society per acre of flood-source land becomes $1,040.

6. The upstream flood-control work has been highly successful in preventing the recurrence of mud-rock floods in all of the watersheds where treatment was applied intensively. Since treatment, these areas have been subjected to a number of high-intensity summer rains, some of greater intensity than ever before recorded in the State of Utah. These torrential rains failed to produce any appreciable amount of overland flow from the intensively treated areas but caused mud-rock floods from untreated or inadequately treated watersheds.

7. Concurrently with the application of remedial measures on the watersheds, plots were set out to measure the amount of storm runoff and eroded soil. Some plots were set out on depleted and eroding lands that were considered to be flood-source areas, and some on well-covered, noneroding lands that were considered to be nonflood-source areas. Records from these plots during the 10-year period 1936-46 showed the depleted areas to be incapable of controlling storm runoff and erosion whereas there was virtually no storm runoff or soil loss on the well-vegetated plots. In 1947 some of the flood-source plots were mulched with straw and seeded to grass and some of the nonflood-source areas were stripped of all ground cover. Restoring the plant cover on eroding areas reduced storm runoff and stopped erosion. Denuding noneroding plots converted them to producers of large quantities of storm runoff and sediment. These plots have demonstrated that plant cover is essential for controlling storm runoff and for keeping soil in place.

8. The Centerville watershed, one of the drainage basins near the southern edge of the experimental area, provides a strikingly different example of watershed management. Years ago, the people of Centerville acquired title to part of the lands in Centerville Canyon. They arranged for conservative grazing in the watershed. In contrast to the unmanaged, excessive use of the forage in the other watersheds, the plant cover in Centerville Canyon has been maintained in a healthy condition. Centerville Creek has produced no mud-rock floods in historic times, though rainfall records show it has been subjected to very high rates of rainfall in recent years. The people of Centerville by fostering wise use of the watershed lands have escaped serious flood damage and at the same time have enjoyed the benefits of the mountain land resources. In the other watersheds, misuse of the plant cover caused great damage and required large expenditures of public funds for restoration purposes.

9. The experimental area is now serving not only as a classic example of what can happen to watershed lands under poor and good management, but also as an outdoor watershed laboratory for determining the best methods of handling steep mountain lands for the control of floods and the production of maximum yields of useful water.

WATERSHED TOUR

Many interesting features of the Davis County Experimental Watershed can be observed in a tour over the area. It is recommended that the trip start in the town of Centerville and proceed northward to the town of Farmington, then follow the Farmington Canyon Road as shown in red on the map. The encircled numbers shown on the map refer to points of interest that can be seen en route. Following are brief statements about these points of interest in the numbered order indicated on the map.

> **CAUTION**
>
> The Farmington Canyon Road is steep and winding in many places. Persons making the tour are urged to use cars that have effective engine compression and good brakes.
>
> DRIVE CAREFULLY

(1) Centerville.--The most intensively developed portion of this community is situated at the mouth of the 2,026-acre Centerville watershed--a location that makes the community highly vulnerable to flood damage. However, Centerville Creek has produced no damaging mud-rock floods since settlement began in the area more than 100 years ago. The Centerville watershed lands have been kept in good condition through moderate use of the range forage. Streamflow from the canyon has been consistently clear and usable. The water yields have averaged about 12 inches per acre of watershed land, or 2,000 acre feet per year.

(2) Mouth of Parrish Creek.--This 1,378-acre watershed produced four mud-rock floods in the summer of 1930. These floods deposited 330 acre feet of rock and other debris on 260 acres of valley land. The damage caused by these floods, including losses in property values, totalled $336,497.

The large rocks, some more than 100 tons in weight, carried by the floods are visible between the Centerville School and the mouth of the canyon. They were deposited upon rich farmland that had developed from fine sediments which were laid down in the waters of the ancient Lake Bonneville. Absence of similar large rock deposits on the land surface prior to the 1930 floods clearly showed the recent mud-rock floods to be of unprecedented violence since the disappearance of Lake Bonneville, which geologists estimate occurred some 10,000 years ago.

This watershed has produced no mud-rock floods since depleted portions of the headwater lands were contour trenched and reseeded in 1934. That the upstream improvement measures have been effective in preventing additional floods is evident when it is considered that other untreated watersheds have continued to flood during rains of no greater volume or intensity than several which have been recorded in the Parrish watershed since 1934. This watershed is now producing clear, usable water comparable to the high-quality streamflow from the Centerville watershed adjacent to it on the south.

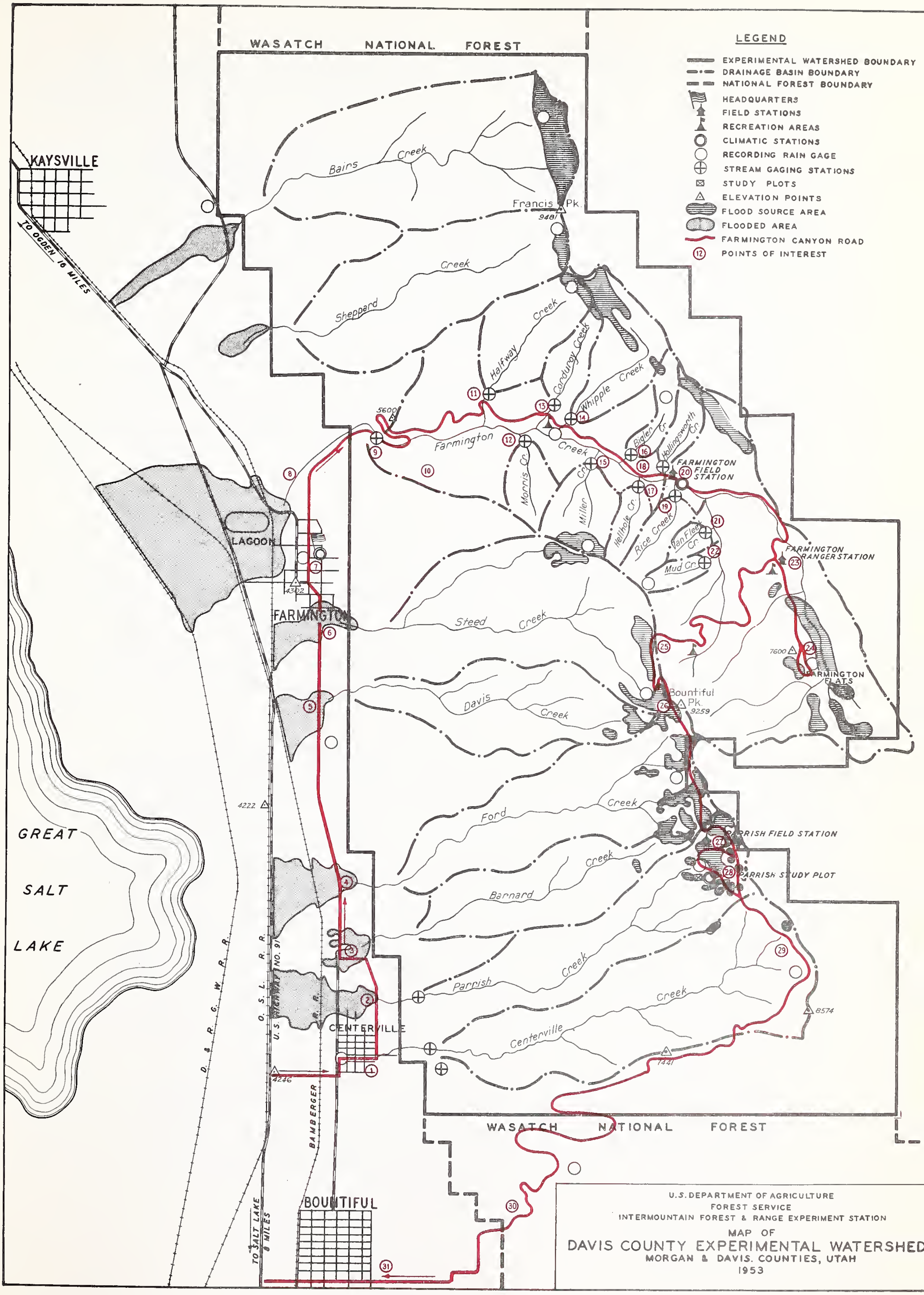
(3) Mouth of Barnard Creek.--This 889-acre watershed flooded in 1923 and again in 1930, causing $13,290 damage. Some of the 53 acre feet of rocks and other flood debris that were deposited on about 75 acres of valley land are still visible in the orchards below the mouth of the canyon. No floods have occurred here since rehabilitation work on the headwater lands was completed in 1935.

(4) Mouth of Ford Creek.--Several mud-rock floods have issued from this 1,507-acre watershed. Those that occurred between 1923 and 1934 were especially destructive. They deposited 185 acre feet of rock and debris on 205 acres of valley land, destroying several fine homes and farms. The flood damages totalled $278,422. Contour trenching and seeding on the flood-source areas in the headwaters was completed in 1935. No floods have occurred since then, though the watershed has been subjected to several violent summer rains.

Debris basins were constructed on both sides of the highway below the mouth of this canyon in 1933 to trap sediment and control future floods. The upper debris basin has been effective in trapping gravel and sand but the value of debris basins for controlling mud-rock floods under conditions found here is questionable. Heavily laden mud-rock floods do not behave like ordinary flood waters in that they do not always flow downhill on the steepest gradient. The flows may be so viscous as to be blocked and diverted out of channels and depressions. In 1936, for example, a mud-rock flood from Willard Canyon, north of Ogden, Utah, which occurred before the watershed was contour trenched and seeded, flowed over the side of a debris basin instead of passing out through the spillway at the lower end. The aim of the upstream watershed improvement work is to prevent floods from developing.

(5) Mouth of Davis Creek.--This 1,005-acre watershed flooded in 1923 and again in 1930, depositing 125 acre feet of debris on 115 acres of valley lands, and causing $118,682 damage. Upstream treatment of the headwater flood-source areas has prevented the recurrence of these destructive discharges.

(6) Mouth of Steed Creek.--Floods from this 1,767-acre watershed between 1923 and 1930, covered 95 acres of valley land with 190 acre feet of debris and caused $80,463 damage. Intensive upstream treatment of the headwater lands has provided effective control of summer floods in this drainage basin.



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MAP OF
DAVIS COUNTY EXPERIMENTAL WATERSHED
MORGAN & DAVIS COUNTIES, UTAH
1953

(7) Headquarters.--The large white building east of the road is a combination office, laboratory, and warehouse. It is the headquarters of the Wasatch Research Center.

(8) Farmington Debris Basin.--A flood debris catchment basin is visible to the west of the mountain road near the mouth of Farmington Canyon. During the period 1923 to 1946, inclusive (24 years), 578 acre feet of sediment were deposited on 875 acres of land below the mouth of Farmington Canyon. This includes deposits within the debris basin and on the lands below it. Sediment production has been at the rate of 2.4 acre feet per square mile of watershed land per year. If Farmington Creek, which drains a 6,322-acre watershed, had been carrying this much sediment for the past 10,000 years since the recession of Lake Bonneville, there would now be an alluvial cone of coarse rock, gravel, and sand 100 feet deep and covering an area of 2,400 acres. The absence of such material and the presence of only rich black soil in and around the Lagoon resort area clearly indicates the present rate of sediment production has been greatly accelerated over the normal.

Floods from Farmington Canyon, 1923-30, claimed the lives of six people and did $226,235 of damage. No major floods have issued from this canyon in recent years, though large quantities of sediment are continuing to be transported into the debris basin from the stream channel which is not stable at the present time.

Since 1930 about $60,000 has been spent in the debris basin to strengthen the spillway and to clean out some of accumulated sediments.

(9) Farmington Stream Gaging Station.--This self-cleaning, masonry flume is used to measure streamflow from the 6,322 acres of watershed land draining into Farmington Creek. Pipes from the bottom and sides of this flume connect water in the stream to a well under the small house beside the flume. An instrument in the house equipped with a float, pen, clock, and moving chart makes a continuous record of fluctuations in streamflow. The rate and total amount of stream flow can be calculated from this record. Records covering the period 1940-49 show the annual yield of water from the watershed averages about 24 inches or 2 acre feet per acre. This is about two times the yield from the Centerville and Parrish Creek watersheds because the Farmington watershed has proportionately more of its area at higher elevations where snowfall is greater.

(10) Gullied Slopes.-- Several deep gullies are visible on the side of Farmington Canyon opposite the road location. These were carved by water flowing from breaks in a pipeline that carried water to a hydroelectric generating plant near the mouth of the canyon. The power plant was dismantled several years ago.

(11) Halfway Bridge.--Halfway Creek, one of the several tributaries to Farmington Creek, is an actively flooding stream. It produced mud-rock floods in 1923, 1936, and again in 1947. The 1947 flood more than filled the deep channel under the bridge and moved the wooden portion of the bridge 3 feet downstream. The flood had a cross sectional area of 224 square feet where it passed the stream gaging station, which is visible a short distance upstream from the bridge. This flood occurred on August 10, 1947 as a result of a summer storm that deposited only 0.79 inch of rain in a recording gage in the head of the watershed. The maximum 5-minute intensity at this gage was 4.92 inches per hour. The flood waters originated as overland flow on about 60 acres of the headwater lands that are still in seriously depleted condition.

This watershed, like the others in this area, yields 98 to 99 percent of the annual runoff as seepage flow that is derived mostly from the melting of snow and from low-intensity fall and spring rains. This type of runoff is of high quality because it is filtered through the soil and rock mantle and is yielded slowly. For example, the maximum flow of this creek during the melting of some 40 inches of snow water in the spring of 1952 was sufficient to raise the water in the 1-foot wide weir at the gaging station to a depth of only 2.3 feet. By contrast, the summer storm flood of August 10, 1947 had a cross sectional area 100 times greater.

(12) Morris Creek Watershed.--This 167-acre watershed is visible on the south side of Farmington Canyon. Note the very steep slopes and the dense cover of trees and brush. Every year, this catchment area receives about 30 inches of precipitation, much of it as snow during the winter months. About 18 inches of this water is extracted from the soil by evaporation and the transpiration of plants. The remainder of the water from snow and rain, about 12 inches, seeps from the mantle as a clear-flowing tributary of Farmington Creek. The very steep slopes are subject to the same high-intensity rains as are other watersheds in the area. However, the dense plant cover on the watershed slopes prevents the occurrence of overland flow and keeps the soil in place. Measurements show sediment production from this watershed to be 0.0004 acre-foot per square mile of watershed per year. The current rate of 2.4 acre feet of sediment production from Farmington Canyon as a whole is 6,000 times greater and indicates the tremendous erosion potential of steep lands if the protective cover of vegetation is reduced below safe limits.

Note: Points numbered 13, 14, 15, 16, 17, 18, 19, 21, and 22, refer to nine other stream gaging stations situated on other tributaries of Farmington Creek, as shown on the map. These small watersheds provide areas for studying the effects of different kinds of plant cover and land treatments on streamflow behavior. Some of these stations are currently not in operation.

(20) Farmington Field Station.--A chalet-type cabin near Farmington Creek is visible from the road. This cabin provides shelter for technicians during the winter months when they hike into the area to get measurements of snow and streamflow. It is also a central point for more detailed studies during the summer season. Nearby, on both north-facing and south-facing slopes, are concrete-lined pits for studying the amount of water that is evaporated and transpired from the soil mantle and the amount that is available for streamflow. Here also is a battery of climatic instruments for getting continuous records of temperature, rainfall rates, and total precipitation. The annual precipitation in this locality for the period 1940-52 has averaged 44.09 inches. The most intense rainfall so far recorded in Utah occurred here on August 10, 1947. At that time, 0.7 inch of rain fell in 5 minutes. This is at the rate of 8.4 inches per hour. Summer rainfall records are obtained at 20 other locations within and adjacent to the experimental watershed.

(23) Farmington Ranger Station.--The Wasatch National Forest maintains a guard at this station during the summer months to supervise the recreational areas, to prevent grazing trespass, and to guard against fire.

(24) Farmington Flats.-- This gently sloping upper valley was one of the main sources of storm runoff that caused the destructive mud-rock flood in Farmington in 1923. Both cattle and sheep concentrated in this locality and drastically depleted the plant cover. Good forage species were replaced by thin stands of tarweed (Madia glomerata) and knotweed (Polygonum douglasii) which had little forage value and were ineffective for controlling storm runoff and erosion.

First attempts to reseed this area largely failed because of the persistence of the tarweed. From continued study it was found that tarweed could be controlled by early-season cultivation and fall sowing of grass. Several species of grass have been found to be adaptable to this area, including smooth brome (Bromus inermis), mountain brome (B. carinatus), intermediate wheatgrass (Agropyron intermedium), orchardgrass (Dactylis glomerata), and tall oatgrass (Arrhenatherum elatius).

A luxuriant stand of grasses and broadleaved herbs as well as many young aspen trees are now present on most of the lands surrounding Farmington Flats. Up to 1936, when livestock were excluded from this area, there was virtually no aspen reproduction or desirable forage plants under the aspen forest canopy. The many dead aspen trees visible from the road were killed in recent years in part by a virus and in part by a borer.

Studies have been initiated in the Farmington Flats area to determine which kinds of grasses are best adapted for reseeding in that and similar localities. Studies are also under way to determine the effects of forage utilization on the amount of water consumed by plants and the amount of water that is available for streamflow. Other tests are planned for the future on this area.

> Note: We recommend that visitors double back on the road to the Farmington Ranger Station, turn left at the road junction and follow the road to the west.

(25) Farmington-Steed Creek Divide.—Immediately below this high pass in the main ridge is a small glacial lake and a beaver pond. The town of Morgan can be seen farther to the east. On the distant horizon to the southeast are the high Uinta Mountains, the longest east-west mountain range in the United States and the highest in Utah. Kings Peak near the center of the range has an elevation of 13,498 feet.

(26) Bountiful Peak Outlook.—This outlook provides a vantage point for observing close at hand the contour trenches and reseeding that was done to prevent the recurrence of mud-rock floods in the Ford Creek and Steed Creek watersheds. It also provides a scenic view of Great Salt Lake. Bountiful Peak to the east (elevation 9,259 feet) and the spur ridge to the west of the outlook, provide other vantage points for viewing the scenery.

To the northwest can be seen the Weber River delta which extends into Great Salt Lake. In the distance beyond the delta is Promontory Range which juts into Great Salt Lake from the north. The Southern Pacific Railroad crosses the southern tip of Promontory Range and extends westward on a trestle across Great Salt Lake. To the west can be seen the several islands in Great Salt Lake, the nearest and largest being Antelope Island. To the southwest is the Oquirrh (Oker) mountain range, the northern end of which lies adjacent to the southern shore of Great Salt Lake. On a clear day, Bingham Canyon and the large open pit copper mine can be seen on the east slope of the Oquirrh Mountains. The spur ridge that extends westward from the main Wasatch Mountains, about 12 miles to the south, obscures Salt Lake City from view.

Immediately below the outlook to the north and to the south, as well as on more distant slopes, are the flood-control contour trenches. Note their patchy distribution. They were installed only on areas which in 1930 showed evidence of excessive storm runoff and erosion and were in such depleted condition as to preclude their recovery by natural revegetation in a reasonable length of time. These areas are part of the 1,300 flood-source acres that were contour trenched and seeded. The contour trenches were designed and installed to trap all of the rain in a 1.5-inch storm. Their purpose was to break up the gully system, to hold the rainwater locally, and thus provide favorable conditions for plant growth. The trenches were constructed mostly by bulldozers driven by CCC enrollees, though steeper slopes were treated by horse-drawn plows and by hand. The contour trenches have been highly effective in fostering a thickening of the vegetation on most of the areas that were virtually bare in 1930. On some very rocky and shallow soil areas, and where much of the topsoil had been eroded away, however, plant recovery is progressing very slowly.

(27) Parrish Field Station.--This cabin provides shelter for technicians during the winter months when trips are made to this area to gather information on snow accumulation. In the summer, it is a center for intensive studies of the effects of plant cover on storm runoff and erosion, evapo-transpiration losses, and the amount of water available for streamflow. The slopes adjacent to this cabin were the site for the first CCC work camp whose members built most of the road and installed the contour trenches.

(28) Parrish Plots.--When the upstream flood control work was initiated in 1934 there was meager information about the climate or the specific effects plant cover exerts on watershed behavior. Various observations, measurements, and experiments were started at the Parrish Plot area and elsewhere on the watersheds to obtain some of this information.

Annual Precipitation

Installation of a network of rain gages and snow stations on the upper slopes of the watersheds within the experimental area as well as at several locations in the valley was begun in 1934. Records from this network show that annual precipitation increases with elevation and that there is much variation in the annual total at the same place from year to year (Table 1).

Table 1.--Average, maximum, and minimum annual precipitation recorded at three stations on and adjacent to the Davis County Experimental Watershed, 1934-52.

Station	Elevation	Annual Precipitation		
		Average	Maximum	Minimum
	(feet)		(inches)	
Headquarters (In Farmington)	4,310	21.74	25.79	16.24
Rice (In Farmington Canyon)	6,975	44.09	54.86	34.59
Parrish (Near Runoff Plots)	8,200	44.81	60.25	35.64

Records from the Rice Station, midway up Farmington Canyon, show that precipitation tends to average about 1 inch per month in midsummer and about 4.50 inches per month in the fall, winter, and spring seasons. The records there also show that about one-fourth of the annual precipitation occurs as rain and three-fourths as snow (Fig.1).

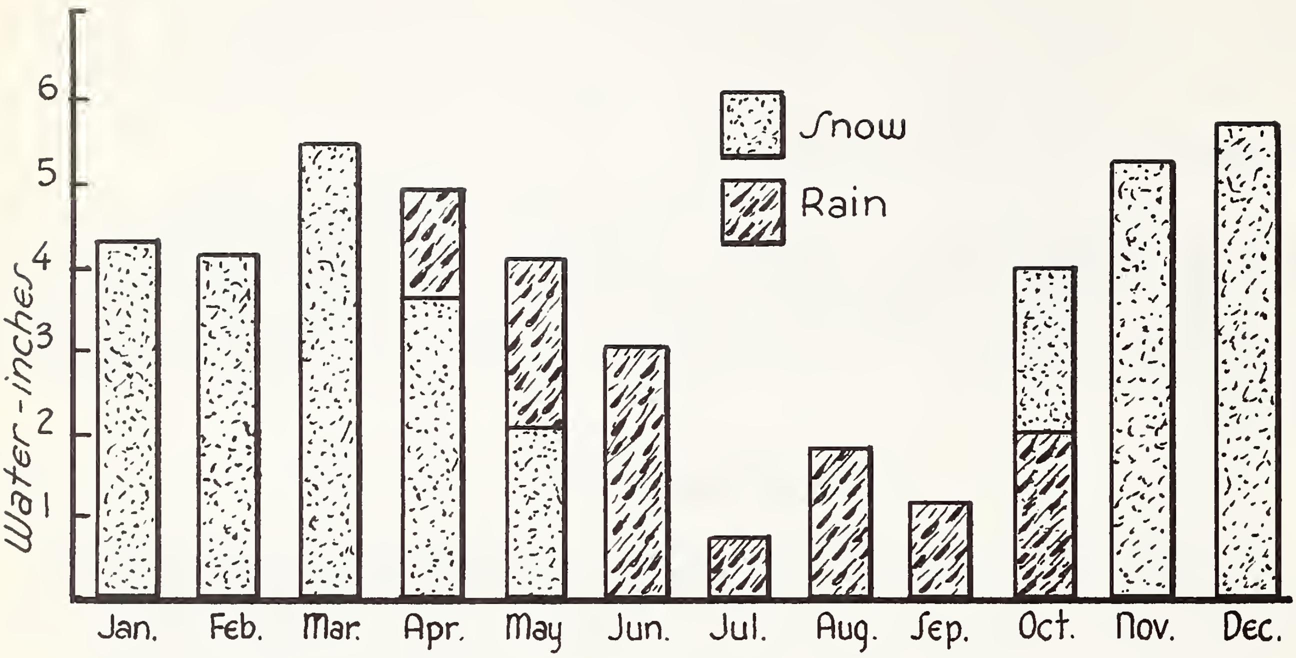

Fig. 1. Average monthly precipitation at Rice Station, 1934-52.

Winter Precipitation and Perennial Streamflow

The precipitation which occurs in the fall, winter, and spring months on lands above about 6,500-feet elevation is the principal source of water for streamflow. Analyses of streamflow, precipitation, and plot records show that this important resource is renewed each year in the following manner.

By the end of the growing season in the fall the soil mantle is usually capable of storing about two inches of water per foot of soil depth. Fall rains and snows partially wet the soil mantle. After November 1, additional snow begins to accumulate on the ground. By April 1, the snow pack usually contains about 20 inches of water. Spring snows and rains add more water to the snow pack and directly to the wet soil after the snow melts.

The water that accumulates in the snow pack together with that from fall and spring rains, though variable in amount from year to year, is more than enough each year to replace the moisture extracted from the soil by evaporation and transpiration during the preceding growing season. The surplus water, or that which is in excess of the amount needed to recharge the soil mantle to its water-holding capacity, becomes available for seepage to springs and channels. It is this surplus water which rejuvenates the flow of streams in the springtime and keeps many of them flowing all summer and on into the next snow-melt period.

There are several reasons why one seasonal surplus of precipitation can produce yearlong streamflow from the watershed lands. First, at the high elevations, snow melts slowly over a period of one to two months so that generally less than 1 inch of water is added to the soil in any one day. Fall and spring rains also generally fall gently and at slow rates. Practically all of the precipitation from snow and rain in the winter season therefore goes into the soil where it falls. There is very little quick delivery of water to channels by overland flow. Instead, the free water reaches springs and channels by seeping through the pore spaces between soil and rock particles. The soil pores are so small and the distance the water must travel in these minute passageways is so great that it takes some of the water a whole year to reach the main channel.

Streamflow records and observations on the land show that 95 to 99 percent of the annual runoff from the watersheds in this experimental area is yielded as seepage flow. Occasionally, as in the spring of 1952 following an exceptionally deep accumulation of snow, seepage flows may reach flood proportions and cause considerable damage. Generally, however, because seepage flow is yielded slowly and in a clear, filtered condition, it is extremely valuable.

Summer Rains and Overland Flow

Summer rains pose many difficult watershed management problems because they can be either beneficial or harmful. These contrasting effects are traceable in part to the amount of summer rainfall, in part to the rate at which the rain falls, and in part also to plant and soil conditions on the land.

Precipitation records at the Parrish Plots show that rainfall during the summer season (June 15 - September 15) averages less than 10 percent of the annual total. The records also show there may be as few as 1 or as many as 23 storms per season and that the amount of rain per storm may range from as little as 0.1 inch to as much as 2.54 inches (Table 2).

Table 2.-- Summer rainfall (June 15 - September 15) at Parrish Plots, 1936-52.

	Average	Maximum	Minimum
Rainstorms (number per season)	13	23	1
Total rain (inches per season)	3.38	7.63	0.10
Rainfall depth (inches per storm)	0.27	2.54	0.01

These relatively small amounts of rainfall are a blessing in that they supplement the moisture retained in the soil after snow disappears and thus keep plants growing through the summer months. Contrary to commonly held belief, soil moisture studies show that summer rainfall is rarely enough to wet the soil mantle beyond its water-holding capacity. Summer rains on these experimental watersheds therefore contribute very little water to streamflow.

Summer rains, however, can produce very violent and destructive floods provided conditions on the watershed are favorable to the generation of overland flow. This type of runoff will occur whenever the rate of rainfall exceeds the rate at which water can be absorbed into the ground.

Self-recording rain gages show that rain can fall at very rapid rates for short periods of time on these watersheds. At the Parrish Plot Station, for example, rainfall rates in excess of 2.50 inches per hour have been recorded on several occasions, and during one storm a rate of 6.84 inches per hour was recorded (Table 3).

Table 3.--Some torrential rains recorded at Parrish Station, 1936-52.

Storm Date	Total Rainfall Depth (Inches)	Maximum for 5 minutes Amount (Inches)	Maximum for 5 minutes Rate (In./hr.)
July 10, 1936	1.14	0.42	5.04
July 16, 1936	0.89	0.23	2.76
August 19, 1945	1.12	0.57	6.84
August 10, 1947	0.65	0.23	2.76
July 10, 1950	0.70	0.35	4.20

The amount of water involved in these high-intensity summer rains is small compared to the many inches of water that accumulates on the land surface in the snow pack during the winter months. However, only a small quantity of water is needed to start a mud-rock flood on these steep watersheds, if the runoff reaches channels quickly as overland flow. For example, on July 4, 1934, a rain of only 0.47-inch depth produced a flood out of Ford Creek which carried boulders nine feet long.

Summer Storm Runoff and Erosion

Whether torrential summer rains cause floods or sink into the ground where they fall to provide moisture for plant growth hinges upon the condition of the plant cover and soil on the watershed slopes. The effect of plant cover in controlling storm runoff and erosion has been under observation for many years.

In 1936, sixteen plots were installed in the upper portion of the Parrish watershed to measure surface runoff and soil erosion. Some of the plots were installed on depleted areas where signs of erosion clearly indicated them to be sources of flood runoff. Other plots were installed on relatively undepleted sites where a lack of erosion evidence indicated they had not contributed significant amounts of storm runoff. After 10 years of records had been obtained, some of the sparsely covered flood-source plots were artifically seeded to grass; on some the plant cover was allowed to increase naturally; and on some the plants were killed by fire. The plant cover was also altered on the nonflood-source plots. On one of these areas all plant cover and litter were removed. On another, only the aspen trees were removed, leaving the herbaceous plants and litter undisturbed. Some other plots were not treated.

The behavior of these plots has demonstrated that plant cover can minimize storm runoff and soil erosion. The records also show that well-vegetated areas having stable soil can be converted to eroding flood sources by removing the plant and litter cover. An example of these effects is shown below in the behavior of two of the plots during two major storms, one of which occurred before and the other after plant cover conditions on the plots had been altered.

Before Treatment

Storm date: July 10, 1936
Total rainfall (inches): 1.14
Maximum rainfall rate (In./hr./5 min.): 5.04

Plot No.	Plant cover condition	Storm runoff (percent)	Soil eroded (Cu.ft./A.)
6.	Depleted annual weeds	40.5	268
7.	Dense aspen, herbs, and litter	0.5	0

After Treatment

Storm date: July 10, 1950
Total rainfall (inches): 0.70
Maximum rainfall rate (In./hr./5 min.): 4.20

Plot No.	Plant cover condition	Storm runoff (percent)	Soil eroded (Cu.ft./A.)
6.	Recovered by grass and aspen	5.3	0
7.	Denuded by cutting and burning	51.8	374

Watershed Protection Requirements

The Parrish Runoff Plots have also supplied information as to how much plant and litter cover is needed to prevent dangerous amounts of summer storm runoff and to keep soils stable. A study was made of 146 storms. It was found that very little soil erosion occurred when less than 5 percent of the rainfall ran off the land as overland flow. In order to accomplish this degree of runoff control during major storms it was also found that 65 percent or more of the ground surface should be covered by plants and litter. The curve in Figure 2 shows how storm runoff increases above the safe amount of 5 percent when the amount of plant and litter cover on the ground is less than 65 percent.

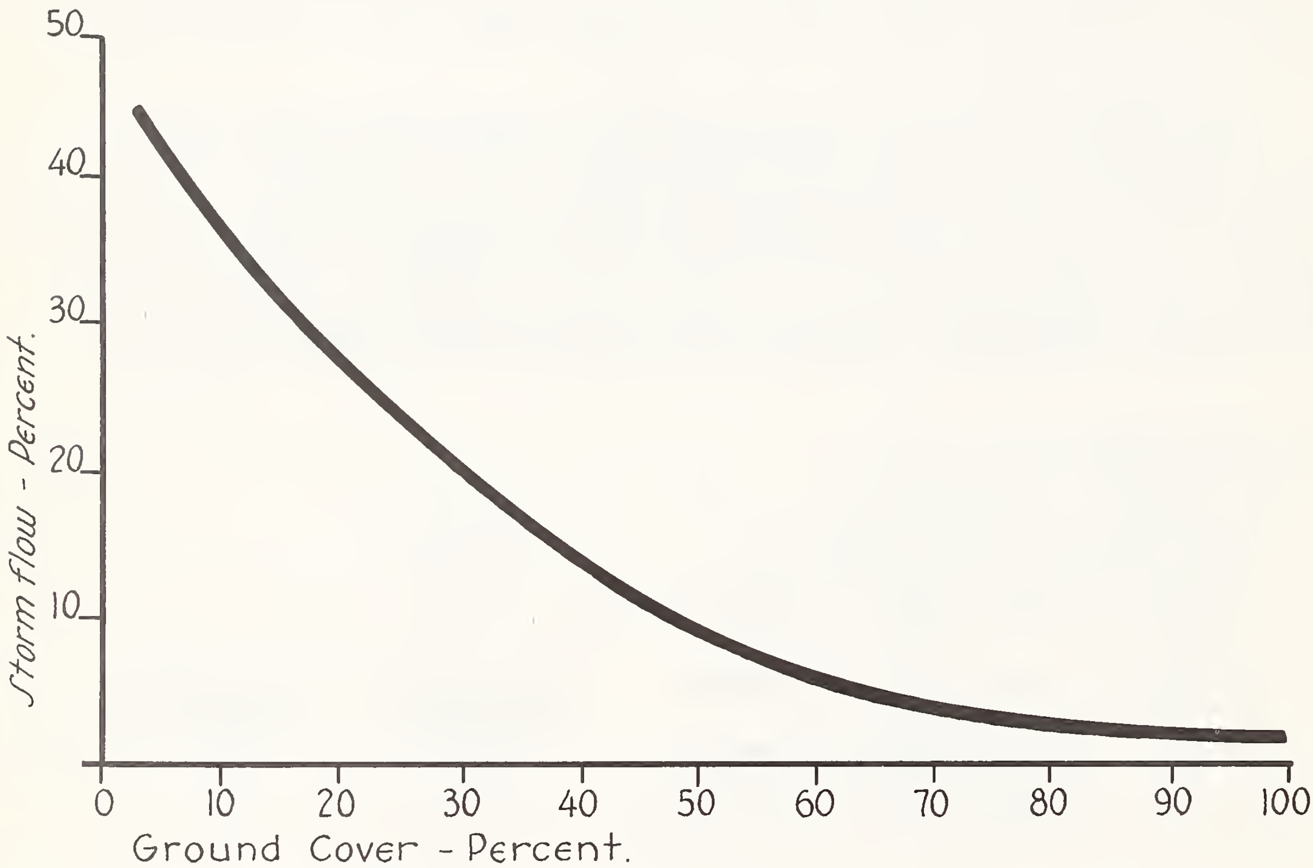

Fig. 2. Relation of summer storm runoff to ground cover based on Parrish Plot data, 1936-52.

Consumptive Use and Water Yields

It is known that plants consume water in their growth processes. One of the major problems in watershed management is to keep these consumptive water uses to a minimum and at the same time maintain enough plant and litter cover on the ground so as to keep soils stable and prevent floods. Solution of this problem requires an understanding of the entire water cycle.

During the years 1947-49 a study was made of the disposition of precipitation on several aspen forest sites. On some of these areas all plant cover and litter were removed. On others, the aspen trees

were cut but the herbaceous plants and litter were not disturbed. On other areas the forest and herbaceous cover was left intact. Data were obtained regarding the amount of precipitation that fell on the study sites, the amount that was lost by evapo-transpiration processes, and the amount of water that became available for streamflow both as overland flow and as seepage flow. Measurements were also made of soil losses (Table 4).

This study revealed that removing the aspen trees reduced consumptive water losses by about 4 inches per year and increased the amount of water available for seepage flow by a like amount without, to date, causing any soil loss. This area is being carefully observed to determine if it will continue to be effective in keeping the soil stable under the impact of a major storm. Until more is known about the future stability of this area, no recommendations will be made for destroying aspen as a watershed measure.

Removing all plant cover and litter further reduced consumptive water losses and increased water available for streamflow but this treatment resulted in catastrophic soil losses. The annual soil losses have averaged more than 6 tons per acre per year and in one storm of only 0.70 inch of rain, there was a loss of 13.5 tons of soil per acre (Table 4). The soil which has been eroded from this bared plot can be seen in the row of barrels nearby. Treatments which bare the soil and set in motion the powerful forces of accelerated erosion obviously have no place in good watershed management.

Table 4.--Average annual precipitation, water losses, and amounts of water available for streamflow on three aspen sites, 1947-49.

COVER CONDITIONS:	Bare	Herbaceous	Aspen
Precipitation (inches):			
Winter (October -- May)	45.43	45.43	45.43
Summer (June - September)	7.34	7.34	7.34
Total	52.77	52.77	52.77
Water losses and uses (inches):			
Snow evaporation	3.00	2.75	2.50
Rainfall interception	0.00	0.77	1.16
Winter transpiration	0.00	0.00	1.00
Summer evapo-transpiration	11.21	14.83	17.70
Total	14.21	18.35	22.36
Water available for streamflow(inches):			
Overland flow	0.40	0.02	0.01
Seepage flow	38.16	34.40	30.40
Total	38.56	34.42	30.41
Soil loss (tons per acre):			
3-year total; 1947-49	18.66	0.00	0.00
Average annual	6.22	0.00	0.00
July 10, 1950 storm (0.70 inch)	13.50	0.00	0.00

(29) Head of Centerville Canyon.--While traversing the head of this watershed, note the denseness and luxuriance of the vegetation. There have been no fires in this canyon for many years. The headwaters have been grazed by sheep each summer until 1951, but in a conservative manner. Recording rain gages show this watershed receives as much and as intense summer rains as the Parrish Creek and other watersheds to the north. However, because it has an excellent covering of vegetation on the headwater slopes, it has produced no mudrock floods in historic times.

(30) Goat Range.--The west-facing slopes immediately above and below the old lake terrace traversed by the road as it approaches Ward Creek near the western boundary of the Wasatch National Forest were grazed by a herd of milk goats until a few years ago. The close grazing by these animals virtually destroyed all of the vegetation except for the tall maples and oakbrush. The people of Bountiful use the water from Ward Creek for part of their domestic water supply. When the water was found to be contaminated, they persuaded the owners of the goat herd to give up their range and grazing operations. The vegetal cover is now slowly thickening. The main grasses are downy cheatgrass (*Bromus tectorum*), three-awn grass (*Aristida fendleriana*), sand dropseed (*Sporobolus cryptandrus*), and bluebunch wheatgrass (*Agropyron spicatum*).

(31) Town of Bountiful.--End of tour.

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